ARS 52-25
April 1969

RELATIONSHIPS BETWEEN GRAIN TRANSIT LOSSES AND BOXCAR DEFECTS

Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

ACKNOWLEDGMENTS

This study was made possible by the cooperation and assistance of the following firms and organizations: Bartlett and Co.; Cargill, Inc.; Central Soya Co.; Continental Grain Co.; Corn Products Co.; Eckhart Milling Co.; Farmers Union Cooperative Marketing Association; Farmers Union Grain Terminal Association; Freight Claim Division, Association of American Railroads; and Simonds-Shields-Theis Grain Co.

Econo-Search Associates, Inc. did the field part of the study. Victor C. Beal, Jr., of the Biometrical Services Staff of the Agricultural Research Service made the statistical analysis of the data. The study was conducted under the general supervision of John E. Clayton, chief, Transportation Research Branch, Transportation and Facilities Research Division, ARS.

CONTENTS

Relationships Between Grain Transit Losses and Boxcar Defects

by Robert F. Guilfoy, Jr., mechanical engineer,
and Robert C. Mongelli, industry economist
Transportation and Facilities Research Division
Agricultural Research Service

SUMMARY

This study was done primarily to guide economic-engineering research aimed at reducing transit losses of grain transported in boxcars. A total of 1,989 incoming cars of wheat, corn, and soybeans were inspected in 1965 and 1966 at grain elevators in Kansas City, Minneapolis, and Chicago. Cars without apparent grain leaks or defects at time of unloading were classified as clear-record cars and all other cars were classified by the type of defect observed.

Of the boxcars inspected, 45 percent were classified as clear-record and 55 percent as defective. Statistical techniques were used to estimate losses and to test the significance of loss-defect relationships. Weight changes between origin and destination for corn and soybean cars were so varied, ranging from a gain of 76,165 pounds to a loss of 33,210 pounds, that definite conclusions concerning losses from defects could not be drawn. However, conclusions could be drawn from analysis of the wheat-car data.

Wheat cars with defective walls had an estimated mean loss of 268 pounds more grain per car than cars without defective walls, and this difference in loss was statistically significant. Cars with defective floors had an estimated mean loss of 360 pounds more grain per car than cars without that defect, and this difference in loss was statistically significant. For boxcars with defective grain doors, the mean loss was estimated to be 202 pounds more per car than for boxcars without defective grain doors, but this difference was not statistically significant. However, the mean loss in cars equipped with paper grain doors was estimated to be 324 pounds more than the mean loss in cars using wooden grain doors, and this difference in loss was statistically significant.

Better car maintenance might reduce losses from defected walls and floors. Losses from paper grain doors might be reduced through improved design or methods of installing the doors. However, further study is needed to determine the feasibility of these remedies and to compare the cost of improving the cars to the value of grain that might be saved.

INTRODUCTION

Losses of weight between origin and destination in shipments of grain by railroad have been a problem for years. For example, an analysis of 13,000 boxcar shipments of grain in 1961-62 showed that 60 percent of the shipments arrived short in weight at destination. [1] Also, railroads paid over $2 million each year from 1959 to 1966 on claims involving grain shipped in defective equipment.[2] Transit losses of grain adversely affect farmers, elevator operators, carriers, and others engaged in the distribution and use of grain and grain

[1] Farmers Cooperative Service. Losses in transporting and handling grain by selected grain marketing cooperatives. U.S. Dept. Agr. Market. Res. Rpt. 766, 22 pp., illus. 1966.

[2] Association of American Railroads, Freight Claim Division. Freight loss and damage. Assoc. Amer. RR. Cir. FCD 2047, 3 pp. 1959-66. (Published annually).

products, and increase the cost of grain products to consumers.

In the past, most grain transported by rail was moved in boxcars, and most transit losses have been associated with boxcar movements. Although covered hopper cars are increasing in number and are hauling an increasing proportion of total rail grain shipments, boxcars are likely to continue for some years to haul a larger part of the grain that moves by railroad. For these reasons, this study was limited to boxcar shipments of grain.

The information was obtained primarily to guide future economic-engineering research undertaken to reduce transit losses of grain by correcting defects in boxcars used to transport grain. Therefore, the relationships sought were those between grain weight losses and three car defects--defective walls, defective floors, and defective grain doors.

The relationships between estimated losses and car defect were tested statistically. The loss figures shown are not intended to be, and of no value as, measures of total transit losses of grain for use in loss and damage claims proceedings. Rather, they are published as added information to aid the reader to understand the loss-defect relationships. All information in the report is published to help carriers, shippers, receivers, and others interested in the problem of grain loss to decide what steps can be taken to do a better job of transporting grain in boxcars.

METHODOLOGY

Two methods were considered as ways to obtain data on grain losses for correlation with defects in rail boxcars used to transport grain. One was to examine existing car-inspection reports on file with carriers and the other was to inspect cars at unloading points. The second method was selected because existing car-inspection records did not contain data in sufficient detail for the purposes of the study.

Time and resource limitations prevented inspecting and gathering data on an unlimited number of cars. After studying a statistical analysis of weight changes in some 200 boxcars of grain shipped by the Commodity Credit Corporation, we decided to obtain data on approximately 2,000 cars. Grain shipments in the cars were divided among wheat, corn, and soybeans in the same ratio that each of these grains had to total railroad shipments for 1963.[3] Data were gathered on cars arriving at three grain terminals--Kansas City, Minneapolis, and Chicago.

Each car was inspected at destination before, during, and after unloading. From the inspection, records were made of defective walls, defective floors, defective grain doors, and whether grain doors were wood or paper. Origin weights (shipper's advised weight) and destination weights were acquired from destination elevator records.

Ten of the elevators in this study used hopper scales to weigh the grain after it was removed from the car. The other used a track scale. All wheat and corn cars, and all but 140 soybean cars, were unloaded at elevators with hopper scales. Weighing methods at the origin elevators were not observed, nor were the bases of the advised origin weights determined.

In the analysis of data to determine the relationship between losses and car defects, the initial step was to group cars by type of grain. Cars without apparent defects at time of unloading were classified as clear-record cars, and all other cars were classified by the type of defect, or combination of defects, observed. From the change in weight between origin and destination, mean losses were determined for cars with and cars without each defect.

The estimated mean losses obtained in this study would not necessarily be expected to occur in a particular movement of cars because of the unknown bases of the origin weight-measurement factors. Further, cars included in the study were not a random sample of boxcars used to haul grain. But the relationships between the various types of defects are based upon accepted statistical techniques and are valid.

---

[3] Interstate Commerce Commission, Bureau of Transport Economics and Statistics. Freight commodity statistics, class I railroads in the United States, for the year ended December 31, 1963. ICC Statement No. 64100, 238 pp.

RESULTS

General

Data were obtained on 1,989 boxcars, including 930 cars of wheat, 818 cars of corn, and 241 cars of soybeans. Table 1 shows that the wheat cars originated from 272 points in 13 States, corn from 278 points in 10 States, and soybeans from 118 points in 6 States. Table 2 shows the average haul and the shortest and longest hauls for the three types of grain. Paper grain doors were used in 47 percent and wood grain doors in 53 percent of the boxcars included in the study.

TABLE 1.--Number of origin points of grain cars, by States

State	Number of origin points of--		
	Wheat cars	Corn cars	Soybean cars
Colorado	2	--	--
Illinois	2	142	35
Indiana	--	10	5
Iowa	2	23	4
Kansas	110	7	--
Minnesota	7	41	68
Missouri	9	2	--
Nebraska	21	48	--
North Dakota	111	2	4
Oklahoma	1	--	--
South Dakota	3	1	2
Texas	1	--	--
Wisconsin	2	2	--
Wyoming	1	--	--
Total	272	278	118

TABLE 2.--Length of haul for boxcars of wheat, corn, and soybeans

Grain	Length of haul		
	Shortest	Longest	Average
	Miles	Miles	Miles
Wheat	15	691	264
Corn	12	476	138
Soybeans	20	309	92

Defects in Cars

Of the 1,989 cars included in the study, 45 percent were "clear-record" cars--that is, cars without observed defects when inspected at the time of unloading. Many of the clear-record cars were either new or had been recently reconditioned. The other 55 percent had defective walls, floors, or gain doors, or combinations of these defects. The percentages shown in the following summary will add up to more than 55 percent because a car might have a given type of defect at more than one location within the car, or more than one type of defect.

Defective Walls

In most boxcars the side and end walls are covered with a lining, usually made of fir or pine board and frequently overlaid with plywood sheeting. Sometimes the overlay is fiberboard, heavy paper, glass fiber, or steel sheets applied to a sufficient height to protect the wall from damage by materials-handling equipment. The type and location of wall defects observed during car inspection are shown below:

Type of defect	Percentage of cars having defect in--		
	Area near doorpost	Sides	Ends
Liner missing...	1	1	3
Liner broken, partly missing or spongy [1] ...	21	12	12

[1] Weakened from previous nailing.

Defective Floors

Many new or recently rebuilt cars equipped with nailable steel flooring leaked at the floor seams because the seams had not been caulked.

The following tabulation shows the percentage of cars with conventional floors and with nailable steel flooring that had certain types of defects.

Type of defect	Percentage of cars having defect
Boxcars with conventional floors:	
Holes or cracks, not patched	12
Holes or cracks, patched but leaking	9
Boxcars with nailable steel flooring, seams leaking	2

Defective grain doors

The following tabulation shows locations of leaks observed in grain doors:

Location of leak	Percentage of cars having defect
Top of door	6
Holes in door	9
Bottom of door	1
Sides of door	2

Unless the posts and adjacent side walls of the cars are in relatively sound condition, the grain doors will be difficult to install, properly, particularly when paper grain doors are used. Following is a summary of defective doorpost conditions observed and types of grain doors used:

Type of doorpost defect	Percentage of cars having defects: With paper door	With wooden door
Posts spongy,[1] split, or broken	13	15
Posts missing	2	4

[1]Weakened from previous nailing.

Estimated Losses From Car Defects

Weight change between origin and destination for corn and soybean cars were so varied, ranging from a gain of 76,165 pounds to a loss of 33,210 pounds, that definite conclusions could not be drawn about the relationships between losses and car defects. Large variations also occurred in the wheat car data, but by eliminating the eight wheat cars with extreme variations (ranging from weight gains in seven cars of 7,750 to 16,280 pounds and to a weight loss in one car of 15,100 pounds), a statistical analysis was possible. Thus, the number of cars was reduced from 930 to 922. The difference in mean losses between wheat cars with and without three types of defects and between cars with wood grain doors and paper grain doors are shown in table 3. A summary of statistical analyses used in the study is included in the appendix.

TABLE 3.--Estimated mean losses from railcar defects in 922 boxcar shipments of wheat

Boxcar loss factor	Cars	Estimated mean loss	Difference in loss
	Number	Pounds	Pounds
Condition of wall:			
Sound	548	281	--
Defective	374	549	* 268
Condition of floor:			
Sound	753	236	--
Defective	169	596	** 360
Condition of grain door:			
Sound	787	314	--
Defective	135	516	202
Grain door material:			
Wood	491	253	--
Paper	431	577	* 324

*Significant at the 5-percent level.
**Significant at the 1-percent level.

Defective Walls

Losses from defective car walls are usually the result of grain being trapped behind the liner where the liner is broken or partly missing. It is also possible that grain falling behind the liner may be lost through holes at the bottom of the space between the liner and outside wall. The mean loss for cars with defective liners was estimated to be 268 pounds greater than for cars without the defect. This difference was statistically significant.

Defective Floors

Losses from defective floors occur as a result of grain falling through holes or cracks. The mean loss in cars with this type of defect was estimated to be 360 pounds greater than in cars without the defect, and this difference was statistically significant.

Defective Grain Doors

Losses from defective grain doors result from grain leakage through holes and cracks or from spillage over the top of the door. The mean loss from this type of defect was estimated to be 202 pounds greater than when the defect was not present. This difference was not statistically significant. However, the analysis showed that losses for cars with paper grain doors were significantly greater than for cars with wooden doors. The mean loss for 431 cars with paper grain doors was estimated at 577 pounds, whereas the mean loss for 491 cars with wooden doors was estimated at 253 pounds, a difference of 324 pounds. This difference was statistically significant.

DISCUSSION

Grain losses from defective car walls and floors could be reduced through better car maintenance and repair. The greater loss from paper grain doors than from wooden grain doors indicates a need to improve the design or method of installing paper doors. Also, the possibility of developing a more suitable door than the present wooden doors and paper doors should not be overlooked. In addition, work might be done to improve the construction of boxcar doorposts and adjacent areas so that these parts of the car can better withstand repeated nailings when grain doors are installed. Further study is needed to determine the feasibility of such improvements, and to compare their cost with the value of grain that might be saved.

APPENDIX

Statistical Analyses

The objective of the analyses was to estimate mean losses, as evidenced by differences in weight change between origin and destination, caused by the following six loss factors: (1) condition of car grain door (sound or defective); (2) condition of car floor (sound or defective); (3) condition of car walls (sound or defective); (4) construction material used for boxcar grain door (paper or wood); (5) number of miles the car traveled; and (6) city at which car was unloaded (one of three cities). Each car was classified according to single factors and combinations of factors applicable to the car.

First Analysis

All of the data collected in the study were included in the first analysis, using the method of least squares with unequal numbers of cars assigned to the various classes. As a result of unusually large experimental errors, the analysis showed no significant differences in losses for the six loss factors included in the analysis. These experimental errors were apparently inflated by errors made in the measurement or recording of weights at origin and were larger for the corn and soybean data than for the wheat data. Accordingly, a decision was made to eliminate cars with unusually large experimental error and to make a second analysis of the data.

Second Analysis

For each of the three grains, data were arranged in a frequency distribution according to the number of cars in various increments of weight change. These distributions revealed that each grain had three peaks, or modes, and this finding provided the means of eliminating cars with the largest errors.

Forty-eight corn cars were eliminated, including 42 cars with gains ranging between 20,745 and 76,165 pounds and six cars with

losses ranging between 20,480 and 33,210 pounds. Twenty-five soybean cars were eliminated. These included 18 cars with gains rangbetween 9,070 and 28,305 pounds and seven cars with losses ranging between 22,960 and 33,035 pounds. Eight wheat cars were eliminated, including seven cars with gains ranging between 7,570 and 16,280 pounds and one car with a loss of 15,100 pounds. No other cars were eliminated because of the impossibility of determining the point at which car elimination would become correlated with the factors causing grain loss.

Results of the second analysis of the corn and soybean data were unsatisfactory because of the continued presence of large experimental errors. The standard error for corn was 4,398 pounds and for soybeans 4,585 pounds. Since no meaningful results could be obtained from the corn and sobyean data, no further analyses for these two grains were made.

In the second analysis of the wheat data, the standard error was found to be 1,020 pounds. This error was not as low as was desired, but it provided a basis on which conclusions could be made. However, the second analysis was based on 3-degrees-of-freedom comparisons for floor and door defects and the interactions between them. This basis did not permit the proper evaluation of the various combinations of loss factors, since there were unequal numbers of cars in the various classes.

Third Analysis

Consequently, a third analysis was performed on the basis of 1-degree-of-freedom comparisons for the various types of defects. The third analysis revealed even fewer significant differences than the second analysis. This result was caused by the unequal number of cars assigned to the various classes with the imbalance being worst for loss factor (6), "city at which car was unloaded." Factor (6) had no significant effect on grain loss and thus could be legitimately omitted from the analysis. Consequently, the third analysis was repeated without this loss factor. More significant differences were then revealed for the loss factors pertaining to defects and door construction material. Results of the third analysis of the wheat data, with loss factor (6) eliminated, are given in tables 4, 5, and 6.

Table 4 shows the least squares analysis of variance and indicates that defective floors, defective walls, grain door construction materials, interaction between door material and defective doors, and regression of loss on miles traveled were significant. Table 5 shows the estimated mean losses for boxcars from defective doors, floors, walls, and door construction material, and from various combinations of these loss factors.

Table 6 shows the significant differences in loss between four single loss factors and two- and three-way interactions of these factors. Grain doors constructed of paper had significantly more loss than those constructed of wood. Aslo, when grain doors were paper and defective, they had significantly more loss than when they were paper and sound or when they were wood and either defective or sound. More significant differences might have been found if more cars had been assigned to some of the classes.

The question arose as to whether the estimated mean losses and the number of cars in each loss-factor group could be correlated. An analysis was made, using the chi-squared contingency table method from Kendall. The results are shown in tables, 7, 8, 9, and 10.

Table 7 indicates a highly significant relationship between a grain door's being constructed of paper or wood and the probability that it will be defective. Table 7 also indicates a smaller relationship between the probability that the walls and floors will be defective concurrently instead of being defective separately. Tables 8, 9, and 10 compare the observed number and percent of boxcars distributed according to factors causing loss and the expected number and frequency of the boxcars if loss factors were not correlated with estimated mean losses.

TABLE 4.--Least squares analysis of variance for estimated mean losses in 922 boxcars of wheat from 5 factors causing loss and from combinations of these factors[1]

Loss factor or combination of factors	Degree of freedom	Sum of squares	Mean square	F-value[2]
Condition of:				
Floor	1	8,506,801	8,506,801	**8.16
Door	1	2,643,311	2,643,311	2.54
Wall	1	4,635,889	4,635,889	*4.45
Floor and door	1	177,283	177,283	.17
Floor and wall	1	3,657,720	3,657,720	3.51
Door and wall	1	180,472	180,472	.17
Floor, door, and wall	1	461,505	461,505	.44
Door construction material	1	6,850,624	6,850,624	*6.57
Door construction material and condition of:				
Floor	1	1,092,532	1,092,532	1.05
Door	1	7,579,960	7,579,960	**7.27
Wall	1	850,606	850,606	.82
Floor and door	1	630,207	630,207	.60
Floor and wall	1	58,653	58,653	.06
Door and wall	1	18,881	18,881	.02
Floor, door, and wall	1	5,202	5,202	.01
Regression of loss on number of miles the boxcar traveled	1	9,263,716	9,263,716	*8.89
Error	905	943,222,100	1,042,234	--

*Effect is significant at the 5-percent level.
**Effect is significant at the 1-percent level.
[1] The loss factors considered are: (1) condition of boxcar grain door, (2) condition of boxcar floor, (3) condition of boxcar walls, (4) construction material used for boxcar grain door, and (5) number of miles the boxcar traveled.
[2] Ratio of the respective mean square to the error mean square.

TABLE 5.--Estimated mean losses in 922 boxcars of wheat from 4 factors causing loss and from combinations of these factors[1]

Line	Loss factor or combination of factors[2]	Number of boxcars	Estimated mean loss	Standard loss error
			Pounds	Pounds
1	S-Wall	548	281	88
2	D-Wall	374	549	91
3	S-Floor	753	236	56
4	D-Floor	169	596	113
5	S-Door	787	314	48
6	D-Door	135	516	117
7	S-Floor and S-Door	647	160	42
8	S-Floor and D-Door	106	309	105
9	D-Floor and S-Door	140	469	87
10	D-Floor and D-Door	29	722	209
11	S-Floor and S-Wall	459	219	72
12	S-Floor and D-Wall	294	250	87
13	D-Floor and S-Wall	89	343	161
14	D-Floor and D-Wall	80	848	160
15	S-Floor, S-Door, and S-Wall	396	160	52
16	S-Floor, S-Door, and D-Wall	251	159	65
17	S-Floor, D-Door, and S-Wall	63	278	134
18	S-Floor, D-Door, and D-Wall	43	340	161
19	D-Floor, S-Door, and S-Wall	77	148	117
20	D-Floor, S-Door, and D-Wall	63	789	129
21	D-Floor, D-Door, and S-Wall	12	539	299
22	D-Floor, D-Door, and D-Wall	17	906	292
23	W-Door	491	253	96
24	P-Door	431	577	82
25	SW-Door	441	323	66
26	DW-Door	50	183	181
27	SP-Door	346	306	71
28	DP-Door	85	848	149
29	S-Door and S-Wall	473	154	64
30	S-Door and D-Wall	314	474	72
31	D-Door and S-Wall	75	408	164
32	D-Door and D-Wall	60	623	167

[1] The loss factors considered are: (1) condition of boxcar grain door, (2) condition of boxcar floor, (3) condition of boxcar walls, and (4) construction material used for boxcar grain door.

[2] S = sound; D = defective; W = wood; P = paper.

TABLE 6.--Differences in estimated mean losses in 922 boxcars of wheat from 4 factors causing loss and from combinations of these factors[1]

Line[2]	Number of loss factors of combination of factors	Loss factor or combination of factors[3]	Estimated mean loss	Difference in loss
			Pounds	Pounds
1	1	S-Wall	281	--
2		D-Wall	549	**268
3	1	S-Floor	236	--
4		D-Floor	596	***360
5	1	S-Door	314	--
6		D-Door	516	202
23	1	W-Door	253	--
24		P-Door	577	**324
7	2	S-Floor and S-Door	160	--
10		D-Floor and D-Door	722	**562
7	2	S-Floor and S-Door	160	--
9		D-Floor and S-Door	469	***309
8	2	S-Floor and D-Door	309	--
10		D-Floor and D-Door	722	*413
11	2	S-Floor and S-Wall	219	--
14		D-Floor and D-Wall	848	***628
12	2	S-Floor and D-Wall	250	--
14		D-Floor and D-Wall	848	***598
13	2	D-Floor and S-Wall	343	--
14		D-Floor and D-Wall	848	**504
29	2	S-Door and S-Wall	154	--
32		D-Door and D-Wall	623	**469
29	2	S-Door and S-Wall	154	--
30		S-Door and D-Wall	474	***320
29	2	S-Door and S-Wall	154	--
31		D-Door and S-Wall	408	***254
26	2	DW-Door	183	--
28		DP-Door	848	**665
27	2	SP-Door	306	--
28		DP-Door	848	***542
25	2	SW-Door	323	--
28		DP-Door	848	***525
19	3	D-Floor, S-Door and S-Wall	148	--
20		D-Floor, S-Door and D-Wall	789	***641
16	3	S-Floor, S-Door and D-Wall	159	--
20		D-Floor, S Door and D Wall	789	***630
15	3	S-Floor, S-Door and S Wall	160	--
20		D-Floor, S-Door and D-Wall	789	***629

*Significant at the 10-percent level.
**Significant at the 5-percent level.
***Significant at the 1-percent level.

[1] The loss factors included are: (1) condition of boxcar grain door, (2) condition of boxcar floor, (3) condition of boxcar walls, and (4) construction material used for boxcar grain door.

[2] See table 5.

[3] S = sound; D = defective; W = wood; P = paper.

TABLE 7.--Chi-squared contingency table of correlations for 1 degree of freedom and various combinations of factors causing grain loss.[1]

Combination of loss factors	Degree of freedom	Chi-squared value
Condition of:		
Floor and door	1	1.05
Floor and wall	1	*3.94
Door and wall	1	.99
Floor, door, and wall	1	1.63
Construction material used for grain door and condition of:		
Door	1	**16.71
Floor	1	.47
Wall	1	.69
Floor and door	1	.01
Floor and wall	1	1.79
Door and wall	1	.68
Floor, door, and wall	1	*4.36
Total	11	32.32

*Significant at the 5-percent level.
**Significant at the 0.1 percent level.
[1]The loss factors considered are: (1) condition of boxcar grain door, (2) condition of boxcar floor, (3) condition of boxcar walls, and (4) construction material used for boxcar grain door.

TABLE 8.--Observed number and percentage of wheat cars classified by 4 factors causing loss, compared to expected number and percentage if there were no correlation with losses[1]

Combination of loss factors[2]	Cars observed		Cars expected	
	Number	Percent	Number	Percent
S-Floor, SW-Door, and S-Wall	225	24.40	203	22.02
S-Floor, SP-Door, and S-Wall	171	18.55	179	19.41
S-Floor, SW-Door, and D-Wall	141	15.29	139	15.08
S-Floor, SP-Door, and D-Wall	110	11.93	122	13.23
S-Floor, DW-Door, and S-Wall	23	2.49	35	3.80
S-Floor, DP-Door, and S-Wall	40	4.34	31	3.36
S-Floor, DW-Door, and D-Wall	16	1.74	24	2.60
S-Floor, DP-Door, and D-Wall	27	2.93	21	2.28
D-Floor, SW-Door, and S-Wall	43	4.66	46	4.99
D-Floor, SP-Door, and S-Wall	34	3.69	40	4.34
D-Floor, SW-Door, and D-Wall	32	3.47	31	3.36
D-Floor, SP-Door, and D-Wall	31	3.36	27	2.93
D-Floor, DW-Door, and S-Wall	7	.76	8	.87
D-Floor, DP-Door, and S-Wall	5	.54	7	.76
D-Floor, DW-Door, and D-Wall	4	.43	5	.54
D-Floor, DP-Door, and D-Wall	13	1.41	4	.43
Total	922	99.99	922	100.00

[1] The loss factors included are: (1) condition of boxcar grain door, (2) condition of boxcar floor, (3) condition of boxcar wall, and (4) construction material used for boxcar grain door.
[2] S = sound; D = defective; W = wood; P = paper.

TABLE 9.--Observed number and percentage of 922 wheat cars classified by the 2 loss factors of boxcar floor condition and wall condition, compared to expected number and percentage if there were no correlation with losses

Combination of loss factors[1]	Cars observed		Cars expected	
	Number	Percent	Number	Percent
S-Floor and S-Wall.....	459	49.78	448	48.59
S-Floor and D-Wall.....	294	31.89	305	33.08
D-Floor and S-Wall.....	89	9.65	100	10.85
D-Floor and D-Wall.....	80	8.68	69	7.48
Total.....	922	100.00	922	100.00

[1] S = sound; D = defective.

TABLE 10.--Observed number and percentage of 922 wheat cars classified by the 2 loss factors of boxcar grain door condition and grain door construction material, compared to expected number and percentage if there were no correlation with losses

Combination of loss factors[1]	Car observed		Car expected	
	Number	Percent	Number	Percent
SW-Door.....	441	47.83	419	45.45
SP-Door.....	346	37.53	368	39.91
DW-Door.....	50	5.42	72	7.81
DP-Door.....	85	9.22	63	6.83
Total.....	922	100.00	922	100.00

[1] S = sound; D = defective; W = wood; P = paper.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
Hyattsville, Maryland 20782

Official Business